# Recycling experiences from Scandinavia, focus on ash from waste incineration and plastics



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# Recycling experiences from Scandinavia, focus on ash from waste incineration and plastics

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**Abstract.** Ash from waste incineration generated when cleaning flue gases contain about 40 w% of water soluble salts, most containing heavy metals like Pb. A method to use the acid scrubber liquid from the air pollution control system to neutralize the alkaline ash has been developed and a full scale demonstration plant is presently being built in Copenhagen, Denmark. The project has partly been financed by EU LIFE. The plant includes steps for metal recycling, mainly Cu and Zn, and removal of chlorides from the washed solid fraction that could be used for construction purposes. Stena Recycling International finance a Professorship in Industrial Material Recycling at Chalmers Technical University in Gothenburg Sweden since more than 10 years back, where most of the research in this area takes place.

Not all thermoplastic waste fractions are clean enough to be mechanically recycled. Feed stock recycling, substitutional fuel and energy recovery are possible alternatives that have been evaluated and tested in Europe. Halogens are in general the biggest challenge since they produce corrosive acids when decomposing due to increased temperature.

In a more Circular Economy materials are material recycled more often than today. No sorting equipment is 100 % correct why low concentrations of contaminants will be able to detect in many recycled materials. Bio test is one efficient method to prove that even though contaminants can be detected the bio availability could be very low. Gene response monitoring has successfully been applied.

## RECYCLING IN EU COUNTRIES

Even if there are differences in the implementation of EU legislations in the different EU countries the overall goal into a more circular economy with less waste, more reuse/repair and more material recycling is very obvious. The landfill ban for waste containing > 10 w% of organics monitored as Total Organic Content (TOC) is already implemented in the northern parts of EU. The reasons for this ban is to reduce risks for fire, reduce risk to produce methane gas due to anaerobic digestion and utilize resources better.

The Landfill directive ban landfilling of inorganic waste containing water soluble salts. Depending on type of salt the maximum content is 10-20 w% why air pollution control ash from waste incinerators either needs some pretreatment or could be landfilled in old salt mines, since they do not contain any water.
Since thermoplastics contain > 10 w% TOC they are not allowed to be landfilled.

## FLUE GAS CLEANING ASH FROM WASTE INCINERATORS, RECYCLING OPTIONS

Some 20 years ago Stena developed a process with the objective to recycle PVC waste. Since PVC contains halogens that form hydrochloric acid when sufficiently heated a process was developed to remove water soluble

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salts from non-water soluble fractions. The process has been modify to treat acid scrubber liquid from the air pollution control system and the alkaline ash generated in the dry part of the gas treatment system. Simplified the steps are as follows:

A Mixing solid ash with water
B Add scrubber liquid
C Precipitate metals from the acidic water solution
D Remove porous water from the solid residue to remove chlorides.

The mass balance depends on what type of air pollution control system that is used, simplified in relation to infeed of gas cleaning ash, the average is:

60 w % solid non water soluble fractions
35 w % water soluble salts, mainly $CaCl_2$. If plant is located close to the sea the salt can be discharged. 5 w% metals, mainly Cu and Zn that can be recycled at a metal smelter.

The first full scale demonstration plant is presently being built in Copenhagen in Denmark and will be in operation year 2019. The capacity is about 10,000 ton/year.

Since flue ash contains leachable heavy metals it is important that the ash is treated in a way that avoids negative impact to the environment. Lead is one element in fly ash that is leachable in water. Since lead year 2018 has been classified as “Substance of Very High Concern” any waste containing > 0.1 w% is classified as hazardous waste.

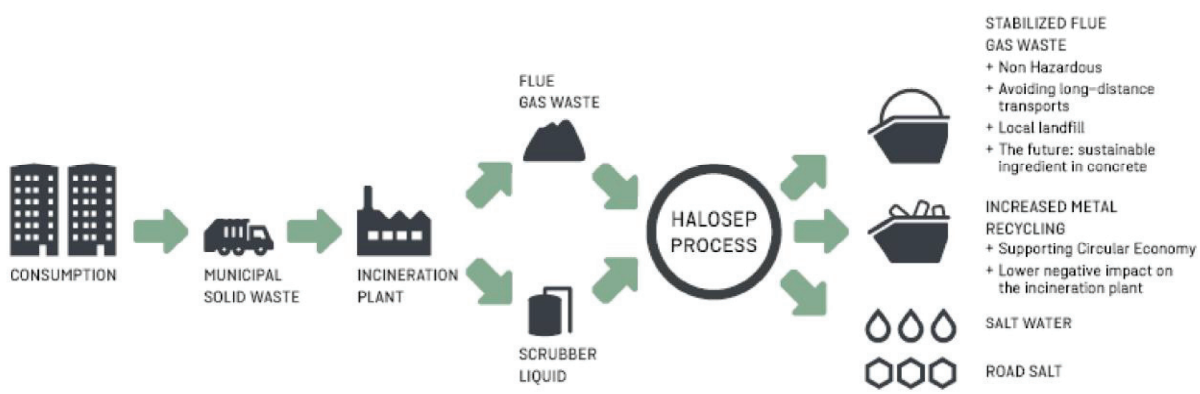


**Figure 1:** Schematic diagram of a municipal solid waste utilization

## RECYCLING OF THERMOPLASTIC MATERIAL

The general recycling steps, Separate-Identify-Sort (SIS) is used for all type of materials, also thermoplastics.

The two most challenging conditions for material recycling of thermoplastic material are sufficient volumes over time and purity. Thermoplastics produced from oil are still cheap compared with high quality recycling. In EU many of the Extended Producer Responsibility (EPR) programs require material recycling of thermoplastic material. Packaging material, electronics and cars are examples of EPR programs that require a large fraction of plastics to be material recycled. EU COM developed graph describing Circular Economy below.

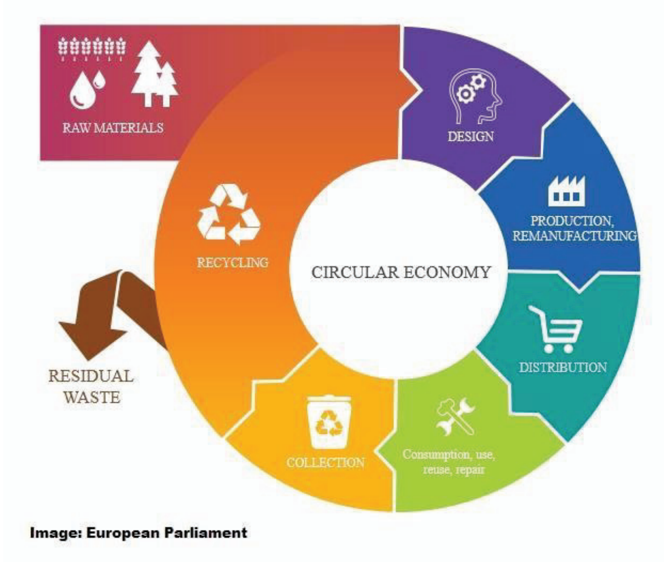


**Figure 2:** EU COM Circular Economy

Identification and sorting is mostly conducted by density differences or sensor based sorting. Only two plastics float in water, Polyethylene (PE) and Polypropylene (PP), if they are not filled with e.g. glass fiber. Also plastics like ABS and PS that contain brominated flame retardants (BFR) can be sorted from non-brominated by sink-float. The density of water is easily increased by adding a water soluble salt, which results in an increased density for water. Plastics with BFR will sink, without will float.

Sensor based sorting using NIR is possible if the plastic is not black. For black plastics combinations of sensors, often X-ray and the last years LIBS are used. The main limitation is the sorting step, limited to a specified size interval.

In many products metals are replaced by plastics that are glass fiber reinforced to reduce weight and cost. If these materials are used in a complex product, like a car, that requires separation technologies like a hammer mill (shredder), these plastics are not possible to material recycle. Plastics separated in a shredder require melt filtration to remove impurities. These filter clog rapidly if plastic contains glass fiber.

To generate a clean plastic from mixed plastics a reject will be produced. Short term energy recovery is the most used method in EU. Long term gasification and production of raw materials for chemicals and plastics is a much better alternative. With present very stringent and to energy recovery adapted legislation, gasification plants have problems in the competition with energy recovery.

## CLASSIFICATION METHODS FOR WASTE

There is in the EU legislation no relation between value and classification as waste or product. In the Waste Framework Directive from year 2008 the definition is: 'waste' means any substance or object which the holder discards or intends or is required to discard. If a waste is classified as non-hazardous or hazardous is mainly based on the chemical legislation, CLP. To simplify if the concentration of a hazardous substance or elements exceeds a limit value, for many elements and compounds 0.1 w% the waste is classified as hazardous.

With the development of new analytical procedures the detection limit is decreasing and in a more circular economy "everything can be found everywhere" this is a big communication challenge. "Same content" as a virgin material is not the same as "same functionality". Small amounts of unwanted elements and compounds do not always indicate problems with the functionality. The resent years the legislation has been changed making it possible to use tests related to bioavailability that could replace chemical analysis. In cooperation with Orebro University a gene response based bio test has been developed and is now ready for standardization. The main benefit compared with other methods is that it is possible to evaluate if a negative impact on a specific organism is due to low/high concentration of harmless compounds like table salt or due to harmful compounds like heavy metals or e.g. Persistent Organic Pollutants (POP). One example of a product that contains a high concentration of a heavy metal but has low availability is a classical crystal glass. It contains about 15 w% lead (Pb) but there is no risk for lead poisoning even if it is used for drinking an acidic wine, the lead is not available for leaching.


**Figure 3**: Classification methods for waste processing

## CONCLUSIONS

To better utilize resources present handling needs to be improved.
New business models with increased Producer responsibility is a vital part of this development. The use of environmentally harmful elements like lead needs to be reduced